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प्लास्टिक अस्तर के जल-कुण्ड की डिजाईन एवं निर्माण — रीति संहिता

Indian Standard

DESIGN AND CONSTRUCTION OF PLASTIC LINED FARM PONDS — CODE OF PRACTICE

ICS 65.040

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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Agriculture and Food Processing Equipments Sectional Committee, FAD 20

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Agriculture and Food Processing Equipments Sectional Committee had been approved by the Food and Agriculture Division Council.

India is a traditional user of ponds, these are small water bodies either man-made or natural water storage structures. They are traditional water harvesting structures. The water stored in ponds is commonly used for drinking water supply, washing/bathing for human and animals, irrigating crops and raising the fish. These small water bodies also play an important role in improving the ecological system and help to maintain biological diversity. In India, approximately 25 lakh ponds are used for a variety of applications. The traditional areas of ponds are in Andhra Pradesh, Karnataka, Tamil Nadu, Orissa and Madhya Pradesh.

Ponds are located on a variety of soil type, which exhibit a wide range of seepage characteristics. The seepage losses in some soil types are as higher as 11 m^3/s per million m^2 area. Seepage losses not only mean loss of useful water but it also leads to other problems such as trench in the embankments, water logging or increased salinity in the adjacent area. With appropriate lining of ponds the seepage loss could be minimized. Plastics can be used very effectively in lining the ponds. But, lining the ponds with plastics as a barrier material, sufficient care is required in selecting the proper material and laying of plastic material and saving it from the damage. In view of the important role played by the plastic film in lining of ponds, it is essential that systematic procedures are to be laid down for plastic lined ponds. It is, therefore, proposed to include all the relevant information on plastic films, design of ponds, subgrade preparation, joining of films and covering technique for plastic lined ponds.

In the formulation of this standard considerable assistance has been derived from Central Institute of Post-Harvest Engineering and Technology, Ludhiana.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

DESIGN AND CONSTRUCTION OF PLASTIC LINED FARM PONDS — CODE OF PRACTICE

1 SCOPE

This standard covers recommendations for design and construction of plastic lined farm pond.

2 REFERENCES

The following standards contain provisions, which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
2530 : 1963	Methods of test for polyethylene moulding materials and polyethylene compounds
2508 : 1984	Low density polyethylene films (*second revision*)
9698 : 1995	Lining of canals with polyethylene film — Code of practice (*first revision*)

3 TERMINOLOGY

3.1 Ageing — Changes in material due to time and environmental conditions, which degrade or improve it.

3.2 Capacity — The maximum volume of water, which a pond can hold.

3.3 Coefficient of Expansion — The fractional change in length of a material for a unit change in temperature that is the length in mm expanded for each mm of total length when the temperature rises 1°C.

3.4 Composite — A plastic structure consisting of two or more different plastic materials mixed together.

3.5 Copolymer — A plastic made by mixing two or more monomers, which polymerizes together.

3.6 Density — The weight of a material per unit volume, that is g/cm^3.

3.7 Design Depth — The depth of the pond for a designed storage volume.

3.8 Elasticity — The tendency of a material to return to it's natural size and shape when a deforming load is removed.

3.9 Elongation — The increase in length of a material being loaded in tension.

3.10 Free Board — The distance between the maximum designed height of water at peak level in the pond and the top of the pond.

3.11 Heat Sealing — The joining of two films by heating processes.

3.12 Impact Resistance — A material's ability to withstand a shock or sudden force.

3.13 Impact Strength — The ability to resist breakage by flexural shock.

3.14 Jointing — The jointing of two films.

3.15 Length of the Roll — The largest dimension of the roll in mm.

3.16 Longevity — Useable life of material is defined as the number of months or years that a material will function effectively.

3.17 Nominal Thickness — Nominal thickness is the theoretically desired thickness of a film for a particular application, its dimension is declared by the manufacturer in millimetres.

3.18 Nominal Width — Normal width is theoretically desired thickness of a film for a particular application, its dimension is declared by the manufacturer in millimetres.

3.19 Permeability — Property of a medium and it is a measure of medium's ability to transmit water through soil under hydraulic gradient.

3.20 Plastic Material — Plastic may be any of numerous organic, synthetic or processed materials that are moulded, casted, extruded, drawn or laminated into objects, films or filaments. At some stage of manufacturing process, all plastics are capable of flowing under heat and pressure.

3.21 Polymer — A long chain compound made up of many repeating units joined together chemically.

3.22 Seepage — The movement of water through soils.

3.23 Shear Strength — The ability of a material to resist tearing.

3.24 Tensile Strength — The ability of a material to resist being pulled apart.

4 TYPES OF POND

4.1 Embankment Pond

An embankment pond is a body of water created by constructing a dam across a stream or watercourse. These ponds usually are build in areas where land slopes range from gentle to moderately steep and where stream valleys are sufficiently depressed to permit the storage of water to a considerable depth.

4.2 Excavated Pond

An excavated pond is a body of water created by excavating a pit be dugout. These, usually, are constructed in relatively flat sands. They are normally used in areas where only a small supply of water is required.

5 DESIGN OF PONDS

To design a pond a careful study is required in respect to the hydrology of the catchment, rainfall-runoff relationship, requirement of water, expected seepage and evaporation losses. The analysis of these parameters will guide to decide the dimensions of the ponds.

5.1 Location

The selection of a pond site should begin with preliminary studies of possible sites. Where more than one site is available, each should be studied separately with a view to select the one that proves most practical and economical. As far as possible, a pond should be located where the largest storage volume can be obtained with the least amount of earth fill. This condition will generally occur at a site where the valley is narrow, side slopes are relatively steep and the slope of valley floor will permit a large deep basin. Such sites tend to minimize the area of shallow water. However, they should be examined carefully for adverse geologic conditions.

a) Irrigation ponds should be located as close to the point of use as is practical. Ponds to be used for fishing should be readily accessible for transportation.

b) Pollution of farm pond water should be avoided by selecting a site where drainage from farm sheds, sewage lines and industrial waste will not reach the ponds. Where this can not be done, drainage from such areas should be diverted away from the pond.

c) The pond should not be located where sudden release of water, due to failure of dam, would result in loss of life, injury to persons or livestock, damage to residences or causes interruptions to public utilities services.

d) Low hanging powerlines may also cause a hazard to fishermen and others using farm ponds. They may not be within the reach of a fishing rod, held by someone at fishing site.

e) A check should be made to insure that no buried pipelines or cables exist in the selected area.

f) The pond should be made at a site where the volume of earth fill and dug-out soil have a matching or least efforts are required in disposing off the excavated soil.

g) The amount of soil that is excavated may be used for making bunds around the ponds. The ponds should have the suitable inlet structure, emergency spillways and other required structures.

In catchment area, water harvesting ponds should be located after studying the contour map of the area so that water from entire catchment may be used up to the maximum possible extent.

5.2 Soil Investigation

Where the pond is to be fed by the surface runoff, relatively impervious soil at the site is essential to avoid excess seepage losses. Clays and silty clays extending below the planned reservoir depth are most desirable and sites with sandy clays usually prove satisfactory. Sites where soils are porous, causes heavy seepage losses in comparison to other conditions; need the lining through impervious material.

The performance of nearby existing ponds in a similar soil is a good indicator of the suitability of a proposed site. Such observations of existing ponds should be supplemented by subsurface investigations. Some indications of the permeability of the soil may be obtained by filling the test holes with water and observing the seepage characteristics of the material.

5.3 Planning

5.3.1 *Capacity of the Pond*

The capacity of the pond is determined by the size of catchment and command area in case of surface runoff ponds and spring discharge in case of spring fed ponds. For runoff ponds, the capacity should be determined by the irrigation demand of the command area or runoff yield of catchment plus provision of evaporation and conveyance losses. The shape of the plastic lined ponds is normally kept as trapezoidal with side slope of 1: 1. If the capacity of the tank is V (m^3) then

$$V=\frac{H}{2}\left[(a-2f)(1-2f)+(l-2H-2f)(a-2H-2f)\right]$$

where

l = top length, in m;
a = top width, in m;
H = depth of tank, in m; and
f = free board, in m.

H should not be less than 1.5 m to avoid excessive water spread area. The upper limit of H is 5.0 m.

5.3.2 *Dimensions*

The dimensions of the pond will depend upon the capacity requirement. The width of the pond will not ordinarily be limited, except that the type and size of the excavating equipment may become a limiting factor. The other dimension may be decided to obtain the required capacity.

5.4 Pond Construction

The pond site should be first cleared of all woody vegetation. The limits of the excavation and spoil placement areas should be stacked and the depth of the cut from the ground surface to the pond bottom should be indicated on the stakes. Excavation and the placement of the dug-out material are the principal items of work required in the construction of pond. The most commonly equipment used for pond excavation are tractor pulled wheeled scrappers, draglines and bulldozers. The use of a bulldozer for excavation is usually limited to relatively small ponds due to its inefficiency in transporting the material. In high rainfall areas and in areas where a ground water table exists with in the limits of excavation, the dragline is most commonly used equipment. The excavation should be made and the dug out material placed as near to the staked lines and grades as skilful operation of the equipment will permit. Where the pond is constructed by a dragline, other types of equipment may be required to shape or spread the waste material. Bulldozers and graders are commonly used for this purpose.

6 PLASTIC MATERIAL FOR LINING

Numerous studies conducted abroad and in India shows that plastic material is quite effective in lining the pond. The plastic material of polyethylene or polyvinyl chloride (PVC) is widely adopted in pond lining.

There are a number of structural, chemical and other miscellaneous properties of the polyethylene and PVC. Heat welding of polyethylene and PVC is possible by heated metal plates, hot gas welding and sonic welding. Polyethylene and PVC are two crystalline polymers that are used as liners for water conservation. Polyethylene provides the low temperature flexibility and toughness needed for most liner applications. If a polymer molecule is symmetrical as to the distribution of its atomic groups, the electrical charges are evenly distributed and the material is not polar and polyethylene, PVC are such materials that can be used in avoiding/reducing seepage.

The salient prospects of the materials are given below:

Property	*Polyethylene*	*Polyvinyl Chloride*
Structure	Crystalline	Crystalline (Plasticized)
Tensile strength	High	Medium to high
Ultimate elongation	Low to medium	Medium
Low temperature flexibility	Excellent	Fair to good
Chemical resistance	Excellent	Good
Solvent weldable	No	No
Heat weldable	Yes	Yes
Dielectrically weldable	No	Yes
Weatherability	Fair to Good	Varies

6.1 Steps of Pond Lining Using Plastic Material

6.1.1 *Desirable Water Barrier Characteristics*

a) Degree of seepage control that can be expected;
b) Resistance to deterioration by soil micro organisms, atmospheric elements (heat, oxygen, sunlight, wind) and subgrade movement;
c) Mechanical puncture and vermin attack;
d) Toxicity;
e) Ease of installation;
f) Transportability with respect to the use of site;
g) Maintenance requirement; and
h) Economy.

6.1.2 *Requirement of Material*

$$\text{Area of the film} = \begin{matrix}\left[2\sqrt{2}(H+f)+1+(a-2H-2f)\right]\times \\ \left[2\sqrt{2}(H+f)+1.00+(l-2H-2f)\right]\end{matrix}$$

where

a = top width, in m;
l = top length, in m;
H = design depth, in m; and
f = free board, in m.

6.1.3 *Subgrade Preparation*

After completing excavation, the bed as well as sides of the pond has to be levelled and prepared for laying the film. Any rocks, large stones or other projections, which might damage the film, should be removed from the bed and sides of the pond. It is important that the bed as well as sloping sides of the pond are well compacted. The side slopes to be lined must be gentle enough to allow covering the layer of sand, gravel or soil placed on top of it to remain in position. On no instance, should the side slope exceed the angle of repose of the embankment material. For weed control suitable weedicide should be sprayed on the bed and side to prevent weed growth beneath the film.

6.2 Joining of Film

Normally the film of required width should be procured to avoid jointing. However, if the film of desired width is not available, the required width can be achieved by jointing the film pieces together. There are various methods of jointing adjacent length of the film to make it completely waterproof. Some of these methods of jointing film have been described in details below. The method adopted depends on its suitability to a particular set of prevailing site conditions.

6.2.1 *Thermal Welding (Heat Sealing)*

As shown in Fig.1 pressure is applied to the film for a pre-determined period through one or two heated jaws or blades, the temperature of which can be adjusted and maintained at a constant level. It is mandatory to place a polytetrafluoroethylene (PTFE) impregnated/ coated glass-cloth between the film and the heating elements to avoid the risk of the film sticking to the blades. The most important parameters in thermal welding are the temperature and the contact time. The graph shows how this contact time varies with temperature of film. It should be noted that as pressure increases, the range of weldability decreases, since it is limited on the one hand, by the onset of fusion while on the other by the destruction of the weld. Currently, thermal welding is the most efficient of all the film jointing methods.

6.2.2 *Jointing by Hot Bitumen*

Films can also be jointed by a coat of bitumen. Bitumen grade 85/25 and 80/100 in the ratio of 2:1 should be heated at a temperature around 100°C. Heated bitumen can be crudely tested on a small piece of film so that overheated bitumen may not damage the film. After ascertaining the appropriateness of the temperature, apply a thick coat of tested bitumen on 10 cm area along the width of both the sheets and fold them as shown in Fig. 2 and cover the same with wide brick masonry.

6.2.3 *Overlapping*

Figure 3 gives the method of overlapping of the film at site for making it impermeable to water leakage. The simple overlap shall not be less than 30 cm for earth cover and 15 cm for hard cover. It is least preferred as overlap joint is prone to leakage.

6.2.4 *Sealing by Adhesive Tapes*

Adjacent lengths of the film can also be jointed with suitable adhesive tapes as shown in Fig. 4. The hydrostatic pressure and the over-layer sufficient to make the overlap practically water-tight.

7 LINING

7.1 Bed Lining

a) If the subgrade is soft and smooth, plastic film is directly spread over the subgrade. However, a 12 mm thick layer of fine sand is recommended to be spread on the subgrade if sharp objects such as stones, pebbles, strong

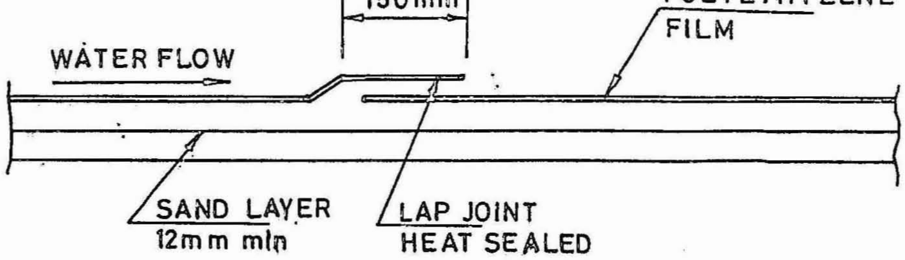


FIG. 1 HEAT SEALING OF JOINTS

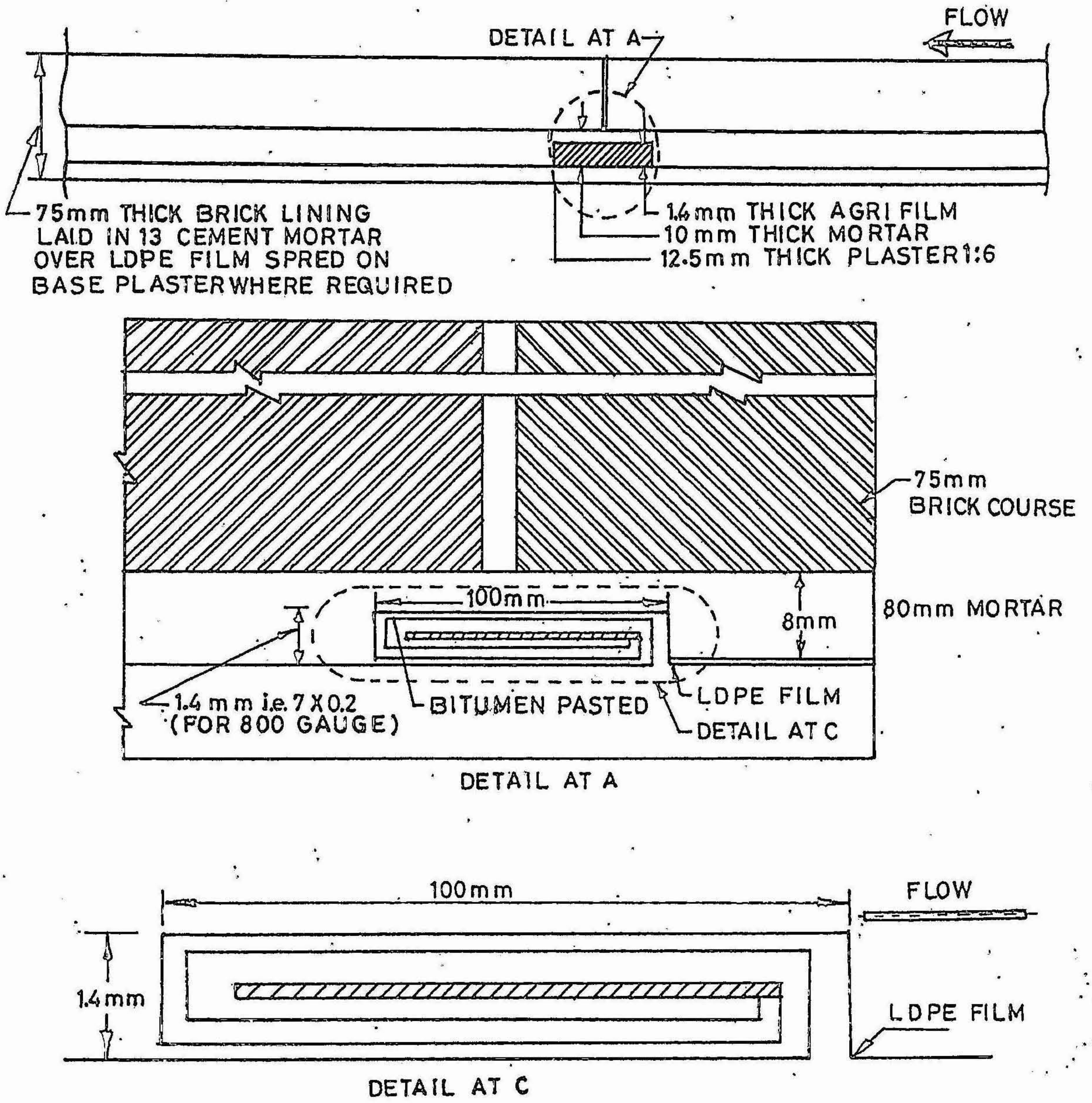


FIG. 2 JOINING BY HOT BITUMEN

weeds are difficult to be eliminated while dressing the subgrade.

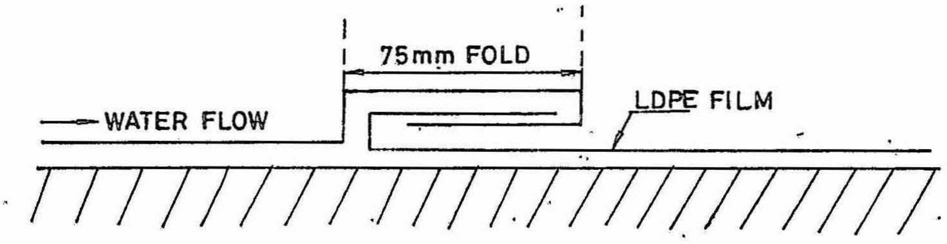
b) Plastic film is spread over the cushioned bed and adjacent layers of the film should be joined.

7.1.1 *Covering Through Tile*

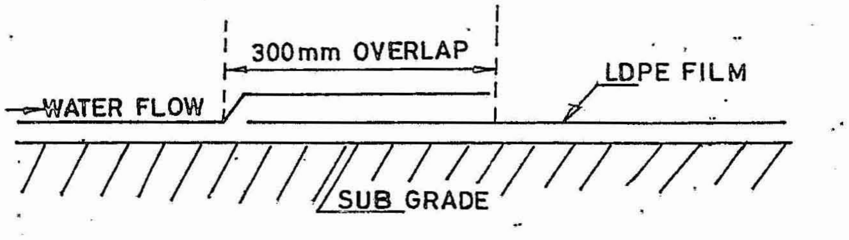
a) Burnt tiles (30 cm × 15 cm × 5 cm) are laid over the plastic film in cement mortar (1 : 5). The mortar thickness below the tiles should be a minimum of 15 mm at any section. Since the film does not allow cement slurry to percolate to the subgrade, the consistency of the cement mortar should be adjusted accordingly.

b) The joints between the tiles should be carefully filled in without puncturing the film. Care must also be taken not to displace the tiles.

c) Walking over the lining, for spraying water, etc, should not be permitted for at least 12 h.



3A Folded Overlap



3B Simple Overlap

FIG. 3 OVERLAPPING METHODS

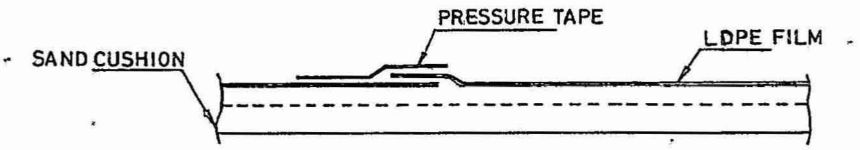


FIG. 4 OVER-LAP JOINT WITH PRESSURE TAPE

7.2 Side Lining

Plastic film is spread over the subgrade directly. One end of the film is anchored in the toe wall. The other end of the film is loosely held at the top of the embankment, at least 30 cm beyond the trench by placing bricks/tiles.

7.2.1 *Covering Through Tile*

a) Burnt tiles (30 cm × 15 cm × 5 cm) are laid directly on the film. Tiles are laid in the cement mortar (1 : 5) of a minimum thickness of 15 mm at any section. The joints are left open. The consistency of the bed should be same as that of the bed.

b) The lining should be cured for 72 h.

c) The loose ends of the film at the top of the embankment should be buried in a trench and covered with masonry concrete.

d) The joints in the tiles should be opened and then filled with cement mortar (1 : 3).

7.3 Plastic Film Lining and Overlaid with Soil Cover

7.3.1 *Subgrade Preparation*

a) A section of the pond should be excavated as per section. The excavated section should be at least deeper by 60 cm than the designed bed level.

b) The suitable all along the perimeter should be well compacted and also reasonably free from the humps and depressions. Sharp objects such as stones, pebbles, roots and weeds should be cleared to prevent puncturing of the film.

c) Excavation beyond the designed bed level should be avoided, as the natural bed provides a suitable compact subgrade.

7.3.2 *Covering Through Plastic Film*

a) A layer of the fine sand should be spread over the well prepared subgrade in order to avoid any damage to the film. The minimum thickness of the sandlayer should be 12 mm depending on the quality of subgrade.

b) Plastic film is spread over the cushion layer. In case of small ponds, the film should be laid lengthwise to avoid/ minimize joints.

c) One end of the film is anchored at the proper position on the bank and then unrolled in a direction perpendicular to flow. Weights in form of cement brick work or ordinary earth should be placed at the corner of every step, till plastic film reaches the anchoring position on the other bank.

d) Spreading of film should be sufficiently loose by providing at least 5 percent extra length.

e) Adjacent layers should be jointed properly.

7.3.3 *Earth Cover*

a) The film on the bed should be covered with the excavated soil. To avoid any damage to the film a 5 cm layer of sieved earth should first be laid and compacted over the film.

b) Rest of the earth cover should be spread over it in 15 cm layers, watered and rammed to avoid breaching effect at the water line.

c) After finishing the profile with well compacted earth, the position of the slope above full supply level may be turfed with durba or chorkata grass as per the availability.

7.4 Plastic Film Lining and Overlaid with Dry Stone Pitching

7.4.1 *Subgrade Preparation*

a) A section of the pond should be excavated as per section. The excavated section should be at least deeper by 60 cm than the designed bed level.

b) The soil all along the perimeter should be well compacted and also reasonably free from the humps and depressions. Sharp objects such as stones, pebbles, roots and weeds should be cleared to prevent puncturing of the film.

c) Excavation beyond the designed bed level should be avoided, as the natural bed provides a suitable compact subgrade.

7.4.2 *Covering Through Plastic Film*

a) A layer of the fine sand should be spread over the well prepared subgrade in order to avoid any damage to the film. The minimum thickness of the sandlayer should be 12 mm depending on the quality of subgrade.

b) Plastic film is spread over the cushion layer. In case of small ponds, the film should be laid lengthwise to avoid/minimize joints.

c) One end of the film is anchored at the proper position on the bank and then unrolled in a direction perpendicular to flow. Weights in form of cement brick work or ordinary earth should be placed at the corner of every step, till plastic film reaches the anchoring position on the other bank.

d) Spreading of film should be sufficiently loose by providing at least 5 percent extra length.

e) Adjacent layers should be jointed properly.

7.4.3 *Earth Cover*

The film on side slopes is covered by dry stone pitching, preferably with round river boulders, in case, the cost of boulders is prohibitive, flat stones may be used. However, while using flat stones, sharp edges must be blunted and caution should be exercised in placement of stones over film to avoid any damage to it.

Stone pitching is started by placing about 20 cm. Thick stones at the bottom of the slope which are settled in the soil cover over bottom LDPE film. The thickness of the stones is gradually reduced, so as the thickness of stones at the top is about 10 cm. The stones are placed in such a manner that they provide a grip to each other. The gap between stones is then filled with soils. After few fillings of water, the soil get settled between stones which not only provides grip to stones but protect the film also. The top 30 cm width of stone pitching is plastered with cement mortar (1 : 6) if the tank site is susceptible to human disturbances. If the depth of tank is more than 2 m, 30 cm wide vertical bond by cement mortar may be provided at an interval of 6 m. This will further protect the stones from any movement due to outside interference.

8 PRECAUTIONS FOR LAYING THE FILM

a) Before laying the film which should be invariably U.V. stabilized and the protective earth cover, the subgrade should be dressed true to level so as to form a firm and even bed for laying of the plastic film. If pebbles or other sharp edged materials or voids are present in the subgrade, a sand cushion of suitable thickness should be provided before laying the plastic film.

b) Before placing the earth cover, the plastic film should be minutely inspected to ensure that there are no perforations present in the film. Any such perforations should be heat sealed with at least 100 mm patch all around it.

c) A protective earth cover of 45 cm should be provided over the plastic film. The protective earth cover should be laid uncompacted. It should be ensured that the protective earth cover does not contain any pebbles or other sharp-edged materials, which may damage the film.

d) Supervisory as well as manual labour should walk on the film barefooted so as not to damage the film. Further, no sharp edged object should be placed or rolled over the film.

e) The plastic film should not be placed when the temperature is below 32°F (0°C) or above 100°F (38°C).

f) The plastic film should be laid with 5 percent slack in both directions, distributed evenly along the length and breadth of the film.
g) While desilting the reservoir (there is a possibility of silt deposit from the reservoir water) care must be taken so that the protective earth cover is not removed and plastic film is exposed.
h) The plastic film should be spread loosely on the subgrade. It is very much essential that the laid film should be covered with earth cover at the end of the day.
j) In areas that are highly weed infected, a suitable anti-weed chemical may be used.

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Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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